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Sustained high incidence of injuries from burns in a densely populated urban slum in Kenya: An emerging public health priority

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Abstract

Introduction—Ninety-five percent of burn deaths occur in low- and middle-income countries (LMICs); however, longitudinal household-level studies have not been done in urban slum settings, where overcrowding and unsafe cook stoves may increase likelihood of injury.

Methods—Using a prospective, population-based disease surveillance system in the urban slum of Kibera in Kenya, we examined the incidence of household-level burns of all severities from 2006–2011.

Results—Of approximately 28,500 enrolled individuals (6000 households), we identified 3072 burns. The overall incidence was 27.9/1000 person-years-of-observation. Children <5 years old sustained burns at 3.8-fold greater rate compared to ($p < 0.001$) those ≥5 years old. Females ≥5 years old sustained burns at a rate that was 1.35-fold ($p < 0.001$) greater than males within the same age distribution. Hospitalizations were uncommon (0.65% of all burns).

Conclusions—The incidence of burns, 10-fold greater than in most published reports from Africa and Asia, suggests that such injuries may contribute more significantly than previously thought to morbidity in LMICs, and may be increased by urbanization. As migration from rural areas into urban slums rapidly increases in many African countries, characterizing and addressing the rising burden of burns is likely to become a public health priority.

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Keywords

Burn; Burn injury; Slum; Population-based; Kenya; Burn rates

1. Introduction

Severe burns from fires alone (not including scalds) account for more than 300,000 deaths annually with approximately 95% of burns occurring in LMICs (low and middle-income countries), where resources to treat and manage injuries are scarce or unavailable [1]. The rate among populations living in urban slum environments is a particular concern because overcrowding increases the potential for infants and toddlers to experience non-intentional burns, especially during cooking where fires can spread rapidly, injuring many people simultaneously. As migration from rural areas to urban slums in many African countries continues at rates of 3–7% per year [2], addressing the rising burden of burn injuries is likely to become a public health priority.

Studies of burn injuries conducted through hospitals and clinics in Africa, Asia and Latin America, including India [3], Pakistan [4], Nepal [5], Nigeria [6], Ghana [7], Sri Lanka [8], South Africa [9], and Peru [10] have highlighted that they are an emerging public health problem. However, documentation of burn injuries of varying severity at the household-level is available only from Ghana [11] and Bangladesh [12]; these studies found substantially higher rates than those that ascertained cases in formal healthcare settings. There have been no longitudinal, prospective studies in an urban slum setting. We carried out a 5-year analysis based on household surveillance data eliciting information about burn injuries of all severities within two villages in Kibera, a large urban slum in Nairobi, Kenya, to define the magnitude of the problem and to inform public health interventions, policy, and future research agendas.

2. Methods

2.1. Population-based surveillance

The United States Centers for Disease Control and Prevention (CDC) and the Kenya medical research institute (KEMRI) have collaborated on population-based infectious disease surveillance (PBIDS) in Kibera since 2005 [2,13]. PBIDS includes both household- and clinic-based surveillance components. Written informed consent was obtained for data collection at the clinics and households. Written informed consent for minors was obtained from their parent or guardian. The protocol and consent forms were reviewed and approved by the ethical review boards of KEMRI (#932) and the Institutional Review Board of the CDC (#4566).

The household study population in Kibera consists of approximately 28,500 (range 25,000–30,000) enrolled individuals, representing about 6000 households living in a surveillance area measuring approximately 0.37 km^2 (population density = 77,000/km^2). Participants in PBIDS were assigned a unique identification number and agreed to regular household interviews conducted by community interviewers (CI's) who systematically collected data into pre-programmed personal digital assistants (PDAs). Interviews included general illness questions about illnesses or events, including whether individuals within the household had sustained a burn or been involved in an injury/accident since the last scheduled household interview, one or two weeks before. Community interviews took place biweekly during the first years of the study. In the final quarter of 2009, a transition was made to weekly interviews in an attempt to limit recall bias, as previously described [14].

Quality-control checks, including independently repeated interviews (by field supervisors), accompanied interviews, automatically generated performance scorecards for each CI (using data collected from the clinic to cross-check and validate data collected on the same illness from the same patient during the home visit), and use of “red herrings” within the interview process (which include listing non-existent residents to be interviewed) to ensure that CI’s were visiting households and completing interviews, were integrated into the system to ensure that interviews are conducted according to protocol, results are consistent, and data are appropriately managed. PDAs were programmed using visual basic .Net 2005 and data stored in an SQL database 2005 (Microsoft, Redmond, WA).

Questions were asked directly of participants ≥5 years of age who were at home at the time of the visit. For participants who were not home or for those <5 years of age, a knowledgeable proxy, typically a parent, spouse, or sibling was asked to respond as a substitute. Whether a participant or proxy completed the interview is noted. When neither the participant nor a suitable proxy was interviewed, the participant was documented as not home for that round, and the interview documented as attempted, but not completed.

The study clinic (Tabitha Clinic, operated by Carolina for Kibera and staffed by the CDC/KEMRI collaboration) provides free outpatient care for all acute illnesses for all participants enrolled in PBIDS, and at a standardized tariff for other residents of Kibera not enrolled in PBIDS or for non-covered conditions. Care for chronic illnesses or traumatic events, including burns, are not covered conditions in the project, so clinic visits for burns are charged at the standard tariff. The clinic uses an electronic medical records system in which clinicians can enter information into a free-text field including chief complaint and past medical history about non-study conditions like burn injuries. Data were collected for clinic surveillance by chart review of these fields.

2.2. Time period

The study period for analysis of the household interview data was July 1, 2006 through June 30, 2011. For the clinic data, visits from July 1, 2006 through March 31, 2010 were analyzed.

2.3. Burn injury case-definitions

For household surveillance, participants were defined as having sustained a unique “burn injury” if they or a proxy answered affirmatively to the question “In the last two weeks, have you had a burn?” during the biweekly reporting period or “In the last week, have you had a burn” during the weekly reporting period and had no history of an affirmative answer to this question within the preceding 14 days. The number of unique burn-injuries from household surveillance provided the numerator for incidence rate calculations. There were no follow-up probe questions about severity or etiology of burn injury during the household surveillance. Questions about hospitalization including number of days in hospital and other healthcare care sought were asked later in the interview and linked to the individual's household data. Because the surveillance is principally designed to characterize the epidemiology of infectious diseases, no additional information was collected during home visit about burn injuries.

For clinic surveillance, patients enrolled in PBIDS who presented to the study clinic with a chief complaint of burn or mention of a burn during either the physical examination or description of symptoms were considered to have sustained a burn injury. Each data record was individually screened to exclude terms such as "heartburn" or "burning", as well as previously reported cases. Information from the clinic visit, including description of etiology (used to construct Table 6), anatomical location, and disposition of the burn injury were collected. These data were not linked to household data.

2.4. Data analysis

Data were managed and analyzed using SAS version 9.2 (Cary, NC) and Microsoft Excel 2007 (Redmond, WA). Burn injuries were identified according to the case definition. The person- years of observation (pyo) used as the denominator for the incidence was calculated as the total person-years of all participants in the PBIDS excluding the reporting periods when an individual or a proxy was not interviewed. The numerator for incidence calculations was derived from the household surveillance data. Households were categorized according to whether there was a history of a burn within that household. The frequency of multiple individuals with burns in the same household was established by sorting cases according to household, as determined by unique ID number and residential ID number. Tests for comparing rates were assessed with exact (mid) p-values. Ninety-five percent confidence intervals for rate ratios were calculated using Byar's approximation [15].

3. Results

In the 3,265,164 household interviews conducted during the study period (with 83% of all scheduled interviews completed), a total of 3072 cases of burn injury events were identified (Table 1) among 110,226 pyo, yielding an overall incidence rate of 27.9 per 1000 pyo (95% CI 26.9–28.9). The burns occurred among 2723 individuals, residing in 2108 households. There were 14,458 residents recorded as residing within the 2108 households during the course of the study. Incidence in females was 1.2-fold greater than in males ($p < 0.001$, Table 2). The burn injury rate was 3.8-fold greater in children <5 years old than in people ≥5 years old ($p < 0.001$); the highest age-associated incidence was in the 12–23 month old age group. Males and females <5 years old had similar rates; however, females ≥5 years old sustained burn injuries at a rate that was 1.35-fold greater than males within the same age distribution ($p < 0.001$). Women aged 18–34 and 35–49 years were at greater risk ($p < 0.001$) of incurring a burn injury compared to males within the same age ranges with risk ratios of 1.89 and 2.09, respectively.

Of the 2108 households in which a resident had a burninjury, 492 (23.4%) had more than one resident burned, with a maximum of 5 household residents with burn injuries (Table 3). Of the 2723 individuals who sustained burn injuries, 288 (10.6%) experienced more than one independent burn injury event within the study period up to a maximum of 10 burns, although only 39 cases had 3 or more burn events (Table 4). Children <5 years old accounted for 40% of surveillance participants who experienced a single burn injury event, as well as 51% of those with 2 independent burn injury events, and 48% of those with ≥3 burn injury events (Table 5). The incidence of a subsequent second burn injury event was 68.1/1000 pyo (2.4-fold greater than the overall incidence rate).

Self-report of hospitalizations from the household inter- view data appeared to be uncommon. There were only 20 identified hospital admissions among the 3072 burns (0.65%) with a mean duration of hospitalization of 9.5 days. Males with a burn injury were 4.7-fold more likely to be hospitalized than females ($p < 0.01$). Gender differences were greatest for males ≥5 years old who had a 7-fold greater likelihood to be hospitalized than females ≥5 years old ($p < 0.01$). There was no significant difference in the likelihood of being hospitalized for males <5 compared to their female counterparts or for individuals ≥5 years old compared to those <5 years old. There were 10 deaths within 7 days of a burn (0.33% of all burns) and 3 between 7 and 90 days of a burn (0.01%). It is not known how many of these deaths were actually caused by the burn injury, since autopsy and death certificate data, specifying cause of death were not available.

Reasons for burn injuries, entered in free-text, were available from the computer-based medical record system at the study clinic, although they were not systematically collected or linked to household cases. Of the 451 clinic cases that were identified, 348 (77%) had no relevant free-text information related to the cause of the burn. For the cases that had this information, most (79%) were associated with cooking with hot oil, other hot fluids, or directly from cooking stoves. Non-cooking related activities resulted in 18% of burns, and a small percentage was related to electrical sources (2%) or assault (2%). (Table 6)

4. Discussion

These findings suggest that burns in urban slums may be an important public health concern in similar settings and that the magnitude may be significantly under-appreciated. To our knowledge, this study provides the first population-based incidence rates for burns in Sub-Saharan Africa. With the growing number of people around the world migrating to urban slums, where limited space for activities like cooking might increase the potential for burn injuries and where fires can spread from residence to residence in seconds, morbidity and mortality due to burn injuries in these settings may be especially underestimated. There are at least 8 million people in Kenya living in urban slums such as Kibera [16]. Extra-polating from the household incidence rate of 27.9 per 1000 persons per year in Kibera, at least 200,000 (27.9 burn/1000 pyo* 8,000,000 people) cases of burns may occur per year within similar densely populated urban Kenyan slums alone.

In our analysis, we found that children under 5 are at greatest risk for burns, and among under-fives, rates were highest in children 12–23 months of age. Previous studies confirm that children under 5 are at greatest risk of burn injuries [7,17–21], and a study from Ghana showed that children 18–23 months have the highest rates of burns, also consistent with our findings [7]. We found that adult women were more at risk than men for burn injuries, while men were hospitalized more often for their burn injuries. Burns rank as one of the top 10 causes of deaths and disability-adjusted life-years for women 15–44 [22], despite the fact that many hospital-based studies report that men suffer from greater rates of mortality than women from burns [23]. The women in the Kenyan urban slum setting are responsible for the daily meal preparation and encounter more opportunities to be burned during cooking than men; thus, it is possible that the sources of burns for men are more severe electrical or fire-related injury. It is also conceivable that differential gender- based patterns in clinical decision-making contributed to the differences observed regarding hospitalization rates. Gender differences vary widely based on geographic, cultural, socio-economic, and environmental attributes, so it is difficult to compare these findings with those conducted in other settings. Irrespective of gender and age, our finding that the incidence of sustaining a second unique burn among the 2723 individuals who had sustained at least one burn was approximately double the incidence of sustaining a burn at all in the entire population suggests that there are other risk factors in the household or occupational environments, beyond what we explored in this study which predispose people to increased risk for burn injury.

Most published rates of burns in LMICs are hospital-based, such as a recent study in Iran, where an extremely low incidence of 0.132 per 1000 person-years [23] for inpatient burn injuries in a community hospital was documented. This rate is more than 200-fold lower than our incidence of household-level burn injuries. In LMICs like Kenya, there is often limited access to health clinics, and other factors such as cost of travel or treatment influence health-seeking behaviors [24,25,26]. Our own finding of only 20 hospitalizations resulting from 3072 household-level burns underscores the effect that sampling bias inherent to hospital-based studies has likely dramatically decreased reported incidence and morbidity. It is therefore important to use caution when using rates in reporting burn injuries since failing to document burn injuries at the community level can grossly underestimate the true scope of the problem. Although the setting in which our study was conducted—an urban slum—has attributes that place people at higher risks for burn injury, we believe that the main reason for the higher incidence rate detected in our study is likely to be more complete ascertainment, resulting from the household-level reporting implemented in this study, representing, active, population-based surveillance.

Compared with other studies utilizing household-level surveillance, our rates of burn injuries in children under 5 years old are approximately 5-fold higher than those reported in Ghana [11] and 10-fold higher than rates from Bangladesh due in part to substantial differences in ascertainment methodology and the broader, more inclusive case-definition of burn injury that we used in this study in Kenya [12]. In Ghana, study personnel first screened mothers about their children’s past history of injury and subsequently required visible scar tissue as verified by a medical student to fulfil their burn injury case definition [11]. The cross-sectional household survey of children in Bangladesh [12] included a burn injury only if treatment was administered or if there was self- reported impairment of normal activities for at least 3 days during the 2 months study period due to the injury.

Because our study was not designed to explore the full range of morbidity and long-term sequelae associated with burns in this setting, the broad case-definition we used for selfreported burn injury within the reporting period may have included injuries of minimal clinical or functional impact. However, it did capture cases that had enough consequence to warrant verbal reporting to a CI, documenting an injury (or what might some might consider an “exposure”) with the potential for severe outcome. The exposure risk is highlighted by the observation that people with one burn-injury were more likely than others to have subsequent burn-injuries. It is possible that some of the burns would not have been detected with more stringent case-definitions, which suggests the need to explore and characterize burn injuries that fall into a category of “minor”. The associated challenge of comparing rates across countries and studies highlights the importance of creating a set of validated questions included in national health surveys and standardized long-term follow-up to systematically classify household-level burn injury severity to allow for valid country-to-country comparisons.

Our clinical data suggest that cooking-related injuries are a major source of burns, consistent with other reviews [27]. A possible intervention for preventing burns is introducing improved cook stove technology. In Kibera, where homes often consist of one room, cooking most often takes place inside on the ground using small stoves or charcoal fires within the very small living space, exposing all household members to burn injuries. Several interventions employing newly designed solid-fuel cook stoves to reduce indoor air pollution have also demonstrated a reduction in burn injuries [28]. A novel cook stove with a contained combustion chamber tested in rural Guatemala from 1992–1994 showed significant reductions in burns [29]. Before the intervention, the burn incidence was 42.1 per 1000 person-years; six months after the intervention, the control groups sustained 35.2 burns per 1000 person-years compared to 18.1 in the intervention group. In this population with high burn injury incidence, even marginal increases in safety from such an intervention could have substantial impact with the added benefit of decreasing exposure to inhaled particulates associated with acute respiratory infection and chronic respiratory disorders [30].

Because we conducted household interviews weekly or biweekly, recall bias is a potential limitation for this analysis. The use of household proxies to report health information for individuals who were not present may also have introduced measurement errors. In addition, 17% of scheduled household interviews did not occur. As a result, burn injury incidence was likely to be underestimated. Additionally, our data on burn injury etiology at that time were collected from clinical notes from a subset of patients, limiting these data to cases that were severe enough to present at the study clinic and whose clinician chose to enter additional data about the injury; thus, the findings may not be representative of all burn injuries analyzed. Probing questions about the etiology and severity of the burn are being incorporated into the household and clinic interview template to address this selection bias in the future.

The results of this study suggest that the burden of burns in the developing world has been substantially underestimated. Using the Kibera community as a representative of urban informal settlements in the developing world, the evidence indicates that burns are a major public health concern, that demands immediate attention. Burn injuries are often devastating. Treatments are costly and can take a very long time, leaving patients with potential long-term disability and loss of income for entire families. Appropriate and effective interventions are urgently needed.

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Table 1

Incidence of burn injury from household-level surveillance.

		Cases (*n*)	(%)	Incidence[a] (95% CI)
	Total	3072	100	27.87 (26.9–28.9)
Sex	Male	1407	45.8	25.17 (23.9–26.5)
	Female	1665	54.2	30.64 (29.2–32.1)
Age	<12 months	245	8.0	75.98 (67–86.1)
	12–23 months	393	12.8	101.27 (91.7–111.8)
	24–59 months	636	20.7	78.4 (72.5–84.7)
	<5 years	**1274**	**41.5**	**81.53 (77.2–86.1)**
	5–9 years	429	14.0	33.49 (30.5–36.8)
	10–17 years	327	10.6	18.94 (17–21.1)
	18–34 years	703	22.9	18.06 (16.8–19.4)
	35–49 years	261	8.5	18.17 (16.1–20.5)
	50 + years	78	2.5	19.74 (15.8–24.6)
	≥5 years	**1798**	**58.5**	**21.23 (20.3–22.2)**

[a]Cases per 1000 person years of observation (pyo).

Table 2

Relative risk of household-level burn injury for select comparison groups.

		Relative risk (95% CI)	P-value
Female vs. male		1.21 (1.13–1.31)	<0.001
< 5 yrs. vs. ≥ 5yrs.		3.84 (3.57–4.13)	<0.001
Female vs.			
male by age	<12months	1.25 (0.97–1.61)	0.084
	12–23months	0.77 (0.63–0.94)	0.009
	24–59months	0.95 (0.81–1.10)	0.480
	<5 years	**0.92 (0.83–1.03)**	**0.153**
	5–9 years	0.96 (0.79–1.15)	0.636
	10–17 years	0.99 (0.79–1.23)	0.904
	18–34 years	1.89 (1.62–2.22)	<0.001
	35–49 years	2.09 (1.64–2.67)	<0.001
	50 + years	1.45 (0.89–2.32)	0.132
	≥ 5 years	**1.35 (1.23–1.49)**	**<0.001**

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Table 3

Frequency of multiple individuals in the same household with burn injuries based on household visit data.

Number of individuals with burns in household	Number of households	(%)
1	1616	76.66
2	385	18.26
3	94	4.46
4	10	0.47
5	3	0.14
Total	2108[a]	100

[a] 2723 people with burns resided in 2108 households.

Table 4

Frequency of burn injury per individual based on household visit data.

Number of unique burns per individual	Number of individuals	(%)
1	2435	89.42
2	249	9.14
3	29	1.07
4	5	0.18
5	2	0.07
6	2	0.07
10	1	0.04
Total	2723[a]	100.00

[a]2723 individuals had a total of 3072 burns.

Table 5

Number of burn injuries by gender and age of victim based on household visit data.

		Burns per individual							
		1 burn		2 burns		3 burns		≥4 burns	
	Age	*n*	(%)	*n*	(%)	*n*	(%)	*n*	(%)
Male	<12 months	130	4.8	6	2.1	0	0.0	0	0.0
	12–23 months	167	6.1	17	5.9	3	7.7	0	0.0
	24–59 months	273	10.0	47	16.3	11	28.2	3	13.6
	<5	**570**	**20.9**	**70**	**24.3**	**14**	**35.9**	**3**	**13.6**
	5–9 years	180	6.6	27	9.4	1	2.6	7	31.8
	10–17 years	129	4.7	12	4.2	0	0.0	0	0.0
	18–34 years	211	7.8	12	4.2	2	5.1	3	13.6
	35–49 years	102	3.8	7	2.4	2	5.1	2	9.1
	50+ years	44	1.6	4	1.4	2	5.1	3	13.6
	≥5	**666**	**24.5**	**62**	**21.5**	**7**	**18.0**	**15**	**68.2**
	Total	**1236**	**45.4**	**132**	**45.8**	**21**	**53.9**	**18**	**81.8**
Female	<12 months	102	3.8	7	2.4	0	0.0	0	0.0
	12–23 months	173	6.4	27	9.4	5	12.8	1	4.6
	24–59 months	254	9.3	42	14.6	6	15.4	0	0.0
	<5	529	19.4	76	26.4	11	28.2	1	4.6
	5–9 years	193	7.1	20	6.9	1	2.6	0	0.0
	10–17 years	174	6.4	12	4.2	0	0.0	0	0.0
	18–34 years	441	16.2	32	11.1	2	5.1	0	0.0
	35–49 years	131	4.8	12	4.2	2	5.1	3	13.6
	50+ years	19	0.7	4	1.4	2	5.1	0	0.0
	≥5	**958**	**35.2**	**80**	**27.8**	**7**	**18.0**	**3**	**13.6**
	Total	**1487**	**54.6**	**156**	**54.2**	**18**	**46.2**	**4**	**18.2**
Total	<12 months	232	8.5	13	4.5	0	0.0	0	0.0
	12–23 months	340	12.5	44	15.3	8	20.5	1	4.6
	24–59 months	527	19.4	89	30.9	17	43.6	3	13.6
	<5	**1099**	**40.4**	**146**	**50.7**	**25**	**64.1**	**4**	**18.2**
	5–9 years	373	13.7	47	16.3	2	5.1	7	31.8
	10–17 years	303	11.1	24	8.3	0	0.0	0	0.0
	18–34 years	652	23.9	44	15.3	4	10.3	3	13.6
	35–49 years	233	8.6	19	6.6	4	10.3	5	22.7
	50+ years	63	2.3	8	2.8	4	10.3	3	13.6
	≥5	**1624**	**59.6**	**142**	**49.3**	**14**	**35.9**	**18**	**81.8**
	Total	**2723**	**100.0**	**288**	**100.0**	**39**	**100.0**	**22**	**100.0**

Table 6

Causes of burn injuries presenting to the study clinic[a]

Etiology	Age							
	0–5 years	**%**	**5–18 years**	**%**	**>18 years**	**%**	**All ages**	**%**
Cooking associated	**28**	87.5	**30**	83.3	**24**	68.6	**82**	79.6
Hot fluids	**25**	78.1	**16**	44.4	**13**	37.1	**54**	52.4
Hot oil	**1**	3.0	**5**	13.9	**9**	25.7	**15**	14.6
Stove-related	**2**	6.2	**9**	25	**2**	5.7	**13**	12.6
Other accidental	**4**	12.5	**5**	13.9	**8**	22.9	**17**	16.5
Electrical	**0**	0	**1**	2.8	**1**	2.9	**2**	1.9
Assault	**0**	0	**0**	0	**2**	5.7	**2**	1.9
Total	**32**		**36**		**35**		**103** [a]	

[a]Those with etiology provided, *n* = 103. Total clinic cases, *n* = 451. These data were collected from clinic records between June 1, 2006 and March 31, 2010.